

Pest Management Alliance Project Final Report
March 1, 2001 – February 28, 2002

Southern San Joaquin Valley
Citrus Pest Management Alliance

Agreement Number: 00-02068

Principal Investigator: Dr. Beth Grafton-Cardwell, Dept. Entomology, UC Riverside

Contractor: California Citrus Research Board
Ted Batkin, President
P.O. Box 230
Visalia, CA 93279
Phone: 559-738-0246
FAX: 559-738-0607
Email: ted@citrusresearch.org

February 28, 2001

Prepared for the California Department of Pesticide Regulation

DISCLAIMER

The statements and conclusions in this report are those of the contractor and not necessarily those of the California Department of Pesticide Regulation. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

ACKNOWLEDGMENTS

California Research Board

Ted Batkin, California Citrus Research Board, P.O. Box 230, Visalia, CA 93279. phone: (559) 738-0246, fax: (559) 738-0607, email: citrusrb@aol.com.

University of California Cooperative Extension and Farm Advisors:

Dr. Beth Grafton-Cardwell, Department of Entomology, University of California Riverside, mailing address: 9240 S. Riverbend Ave., Parlier, CA 93648. Phone: (559) 646-6591, fax: (559) 646-6593, email: bethgc@uckac.edu.

Neil O'Connell, University of California Cooperative Extension, Tulare County, Phone: (559) 733-6484, fax: (559)-733-6720, email: nvoconnell@ucdavis.edu

Craig Kallsen, UCCE Kern County, Phone: (661) 868-6221, fax: (661) 834-9359, email: cekallsen@ucdavis.edu.

Etaferahu Takele, University of California Cooperative Extension, Southern California counties, 21150 Box Springs Road, Suite 202, Moreno Valley, CA 92557-8718. Phone (909) 683-6491 Ext. 243, fax (909) 788-2615, e-mail: takele@ucrcl.ucr.edu.

Field Assistants:

Marjie Bartels (Kern County), Garrett Lehman (Tulare County), Chris Reagan, Janet McClain, Melissa O'Neal (Lindcove Research and Extension Center)

University of California Field Stations:

Louis Whitendale, Superintendent of the Lindcove Research and Extension Center, Exeter, CA. Phone: 559-592-2408, email: llwhitendale@ucdavis.edu.

Pest Control Advisors:

Robert Walther, Entomological Services Inc, (Visalia); Alan Brewer, Pest Control Advisor, (Porterville), Roy Burton (Orosi); Mike Carlisle, Paramount Citrus (Edison); Mark Dames (Orange Cove), Bob Gaddie (Redbank), Jim Gorden and James Lundergan, Pest Management Associates, (Exeter), Paul Giboney, M. Caratan Inc., (Delano); Kristi Harrer, M. Caratan (Delano); Mike Kelly, Entomological Services (Edison); John Pulford, Southern Valley Chemical, (Arvin); Scott Powell, Western Farm Service, (Tipton)

Growers:

Duanne Abe (Orosi), Lee Bailey (Orange Cove), Hodge Black (Edison), Gus Collins (Orange Cove), John Denison (Edison), Dean Gilette (Orange Cove), Keith Harrison, (Fresno), Dennis Johnston (Edison), Dennis McFarlin (Reedley), Bob McKellar (Orange Cove), Leo McKinney (Orange Cove), Al Williams (Visalia).

Industry Supporters:

Bob Elliott, Sunkist Growers, 760 E. Sunkist St., Ontario, CA 91761. (909)-787-3086.

Kevin Olsen, S&J Ranch, P.O. Box 3347, Pinedale, CA 93650. (559) 439-2598

Wally Ewart, California Citrus Quality Council, 210 Magnolia Ave., Suite 3, Auburn, CA 95603. phone: (530)-885-1894, fax: (530) 885-1546, email: ccqc@ix.netcom.com

This report was submitted in fulfillment of DPR agreement 00-02065, the Southern San Joaquin Valley Citrus Pest Management Alliance, by Ted Batkin of the Citrus Research Board under the sponsorship of the California Department of Pesticide Regulation. Work was completed as of February 28, 2002.

Table of Contents

List of Figures	5
List of Tables	6
Executive Summary	7
Body of Report	8
A. Introduction	8
B. Results	9
Objective 1	9
Objective 2	9
Objective 3	15
Objective 4	16
Objective 5	17
C. Discussion	18
D. Summary and Conclusions	19
Project Summary Form	21

List of Figures

Fig. 1. The impact of early season 2001 insecticide treatments for citrus thrips, katydid and glassy-winged sharpshooter on citrus thrips densities and predacious mites in Kern County	22
Fig. 2. Fruit damage due to various arthropod pests (or mechanical damage due to wind scarring and equipment) in the Kern County Orchards. Fig. 2a shows the damage ratings taken while fruit is still on the tree. Fig. 2b. shows the damage ratings of fruit in bins as it was being picked.	24
Fig. 3. Densities of Male scale found on pheromone trap cards throughout the season. Insecticide treatments, <i>Aphytis</i> wasp releases, and the percentage of fruit infested with live California red scale are noted.	25
Fig. 4. The effects of Lorsban in a Kern 2000 orchard versus the effects of Esteem and Admire in a Kern 2001 orchard on <i>Aphytis</i> wasp densities. Counts of <i>Aphytis</i> and <i>Comperiella</i> wasps are collected on yellow sticky cards changed monthly.	27
Fig. 5. Glassy-winged sharpshooter nymph and adult densities in the Kern County demonstration orchards.	28
Fig. 6. The impact of early season 2001 insecticide treatments for citrus thrips, katydid, and citrus red mite on citrus thrips and predacious mites in Tulare County demonstration orchards.	29
Fig. 7. Densities of citrus red mite and predatory mites in several Tulare County demonstration orchards.	31
Fig. 8. Evaluations of fruit damage taken by examining fruit on 20 trees in each orchard in Tulare County.	32
Fig. 9. Densities of male California red scale on pheromone traps collected in the Tulare County orchards in 2001. Insecticide treatments, <i>Aphytis</i> wasp releases, and percentage of fruit infested with scale are noted.	33

List of Tables

Table 1. Pesticide applications and <i>Aphytis</i> wasp releases conducted in the 10 Kern County orchards during 2001. The grower in Orchard 1 is applying insecticides to aggressively reduce GWSS. Orchards 2-4 are releasing <i>Aphytis</i> wasps and conducting a biologically-based IPM program. Orchards 5-7 are minimizing the number of insecticide applications through careful monitoring. Orchards 8-10 tend to use broad spectrum insecticides to control pests.	35
Table 2. The number of katydids seen during a 2 minute search of each of 20 trees in each orchard on several dates before and after insecticide treatments were applied for citrus thrips and/or katydids.	36
Table 3. Percentage of fruit infested with California red scale (% parasitism by <i>Aphytis</i> and <i>Comperiella</i> wasps). Insecticide treatments for California red scale and glassy-winged sharpshooter and <i>Aphytis</i> releases for California red scale are shown.	37
Table 4. Citricola scale densities in the Kern County orchards.	38
Table 5. Densities of katydids seen during a 2 minute search of each of 20 trees in the Tulare County demonstration orchards 2001.	39
Table 6. Pesticide applications and <i>Aphytis</i> wasp releases conducted in the 10 Tulare County orchards during 2001. Orchards 1-3 are releasing <i>Aphytis</i> wasps and conducting a biologically-based IPM program. Orchards 4-7 are minimizing the number of insecticide applications through careful monitoring. Orchards 8-10 tend to use broad spectrum insecticides to control pests.	40
Table 7. Percentage Infestation of citrus fruit with California red scale (% parasitism of 3 rd instar scale by <i>Aphytis</i> and <i>Comperiella</i> wasps).	41
Table 8. Percentage of trees infested with cottony cushion scale in the Tulare County orchards during 2001. Vedalia beetles were present in some orchards until July.	42

EXECUTIVE SUMMARY

During first year of the Southern San Joaquin Valley Citrus Pest Management Alliance Program, insect and mite sampling was initiated on March 1, 2001 in 10 Kern County and 10 Tulare County citrus orchards. The grower and pest control advisor participants met on a monthly basis to discuss the impact of their diverse management strategies.

In the Kern region, three of 10 orchards received *Aphytis* wasp releases for California red scale, and four orchards used a soft insecticide (Success, Veratran, Kryocide) program for citrus thrips and katydid control in this region. During 2001 year, the majority of treatments in the Kern region were for citrus thrips, California red scale and glassy-winged sharpshooter. Citricola scale is emerging as a serious pest in orchards that do not use broad spectrum insecticides. An average of 1.9 pesticides were applied per orchard for citrus pests and an additional 0.6 pesticides were applied for glassy-winged sharpshooter in this area. Glassy-winged sharpshooter (GWSS) is compromising the IPM program in some orchards in this region and we will soon have data to document the economic impact.

The majority of treatments in the Tulare region were for citrus thrips, California red scale, citrus red mite and katydids. Three of 10 orchards received *Aphytis* releases for California red scale control and seven orchards used selective insecticides (Success and low rates of Lorsban) for citrus thrips and katydids in the Tulare region. Cottony cushion scale is the pest that is most likely to disrupt the IPM program in this region due to disruption of vedalia beetle by the insect growth regulator Esteem. A total of 1.7 pesticides were applied per orchard. This is significantly less insecticide use than the Kern region that is experiencing treatments for glassy-winged sharpshooter. Herbicide demonstration plots were established during the fall of 2001 in most of the Tulare County orchards.

The economic analysis of pest management strategies will be initiated after harvest is complete (end of March). Grower and Pest Control Advisor Cooperators met monthly to discuss the pest and natural enemy trends. Two field days for the general public were conducted, one in each region, stressing the biologically-based IPM approach and discussing the disruption of IPM caused by GWSS treatments. Web pages (www.uckac.edu/citrusent) documenting pest densities and the consequences of the various pesticide and natural enemy tactics were updated weekly.

Body of Report

A. Introduction

If we are to increase adoption of Integrated Pest Management (IPM) methods that decrease reliance on broad spectrum pesticides, we must demonstrate to the grower that program strategies are effective and economically viable. In this project, Cooperative Extension personnel have established citrus IPM demonstration areas in Tulare and Kern Counties (Kern was already established in the 2000 field season using Citrus Research Board funding). A group of 10 citrus orchards in each county have been identified that show a range of pest management methods. A portion of the growers utilize broad spectrum pesticides as their main line of defense. A second portion of the growers use *Aphytis* wasp releases for California red scale and carefully chosen selective pesticides for other pests. A third portion of the growers will use a combination of techniques including an occasional broad spectrum pesticide. Monitoring is conducted by UC personnel for California red scale, citricola scale, citrus red mite, citrus thrips, citrus cutworm, katydid, glassy-winged sharpshooter, citrus peelminer, cottony cushion scale, and fruittree leafroller. Activity of predators and parasites and predators is also monitored. The monitoring in Kern County is directed by Craig Kallsen and in Tulare County is directed by Neil O'Connell. This sampling does not replace that currently being conducted by the grower or their PCA (pest control advisor) but is done by UC technicians so that we can compare the consequences of various pest management strategies between orchards. The results of the technician sampling are reported to each cooperator on a weekly basis. The results are also reviewed at monthly informal meetings with the cooperators to provide an overview of pest/beneficial activity, monitoring procedures and treatments. O'Connell, Kallsen and Grafton-Cardwell hold regular field days and update a web site that describes the activities. At the end of the season, the fruit damage is rated and the pack-outs recorded for each orchard. The costs of the various pest management practices will be calculated. The overall goal is to document the results of the various pest management strategies, assess the economics of the strategies, and train and involve growers and PCAs in biologically-based IPM strategies throughout the season.

Project objectives:

Objective 1: Creation and Coordination of Citrus Team

Task 1.1 Create the Citrus Pest Management Alliance Team

Task 1.2 Coordinate activities of the Alliance Team

Objective 2: Field Monitoring of Citrus Orchard Demonstration Sites

Field monitoring is done to evaluate the pest pressures in each of 10 orchards in Kern and Tulare Counties, record the response of the pests to the various management techniques, and evaluate the resulting damage to the fruit.

Task 2.1 Monitor pests and beneficials in 20 demonstration orchards (10 each in Tulare and Kern counties)

Task 2.2 Rear and Release Vedalia Beetles for control of Cottony Cushion Scale

Task 2.3 Evaluate Pest Damage at the End of the Season

Task 2.4 Identify research projects to address emerging pest problems

Objective 3: Evaluate the Efficacy of Various Weed Management Strategies to Reduce Herbicide Use.

Orchard floor management in Tulare County citrus by means of premergent and postemergent herbicides has been a standard practice for many years. Weed species compete with the trees for nutrients and moisture, and with dense vegetation on the orchard floor during the winter there is the perception of increased risk of frost damage to crop and trees. Increasing concerns regarding water quality have focused attention on cultural practices that might be involved in water quality issues. Among these practices is the use of herbicides for weed management. One concern has been the potential for offsite movement of an herbicide and the possibility of contamination of groundwater. Any practice that might mitigate the potential for offsite movement would reduce the possibility for water quality degradation. Recent research has addressed the issue of potential runoff of premergent herbicide applications and these mitigating measures will be demonstrated in this project.

Task 3.1 Demonstrate the efficacy of reduced herbicide use in row middles

Task 3.2 Demonstration of reduced weed germination through relocation of emitters

Task 3.3 Demonstration of reduced numbers of herbicide applications

Objective 4: Economic Evaluation of Pest Management Practices

Citrus growers need to see that the economics of biologically-based pest management are comparable if not better than traditional management techniques that depend solely on broad spectrum pesticides.

Task 4.1 Evaluate the economics of various citrus pest management tactics

Objective 5: Project Outreach and Extension

Using various organizations and methods, information will be provided to citrus growers on the insect population densities, the effects of the pest management practices, new thresholds, and control tactics that are discovered, and the economics of each pest management strategy. The organizations will include UC Extension, the Citrus Research Board, CCQC, CAPCA, and Sunkist. The methods of information dissemination will be web pages, Citrograph and Subtropical Fruit news, faxes, newsletters, brochures, field days, slide shows, and training workshops.

Task 5.1 Field Days and Workshops

Task 5.2 Publications

Task 5.3 Web Pages

B. Results

Objective 1 and Task 1:

Development and Coordination of the southern San Joaquin Valley citrus PMA team:

The primary team members (Neil O'Connell, Craig Kallsen, and Beth Grafton-Cardwell) met with the alliance participants (10 growers and their Pest Control Advisors in each region) monthly and conducted two field days. Twice yearly a citrus IPM workgroup meeting was held in which this project is discussed.

Objective 2 and Task 2: Monitoring insect pests and natural enemies, releasing vedalia beetles, and assessing the fruit damage pests cause in the citrus IPM demonstration sites

A. Preliminary project results.

Kern Region:

Early season Pests. The year 2001 was a fairly severe citrus thrips and katydid year throughout the valley and if both pests were present, Kern county growers responded by using Baythroid (pyrethroid) as their citrus thrips treatment in order to kill two pests with one insecticide treatment (Table 1). Pyrethroids (Baythroid or Danitol) are fairly broad spectrum and have the effect of severely reducing the predatory mites (Fig. 1, Orchards 5, 6, 9, and 10). Success or Veratran + Kryocide are the preferred combination of thrips and katydid treatments in the biologically-based program and these were effective in orchards 2, 3, 4 and 7 and had little or no effect on the predatory mites. Agri-Mek + oil only temporarily suppressed citrus thrips in orchard 8 and was followed up with the organophosphate Cygon. A single application of Baythroid or combination of Success + Baythroid were not effective in orchards 6 and 9, suggesting that citrus thrips are developing resistance to Baythroid in this region. Orchard 1 applied Lannate for glassy-winged sharpshooter control in the early season, eliminating predacious mites and citrus thrips.

Generally, the treatment threshold for citrus thrips in navels is when 5% of the fruit is infested with immature thrips and the predacious mites are $< 0.5/\text{leaf}$ and the threshold is 10% infested fruit if predacious mites are $> 0.5/\text{leaf}$. Orchards 2, 3, 4, 5, 7, and 8 had fairly high levels of predacious mites, but only orchards 2, 3, 6 and 8 waited to spray until fruit infestation with thrips were equal to or greater than this economic threshold. The reasons that growers provided for not waiting until the threshold is reached were that katydids needed control earlier than the thrips and the spray was targeting both pests or because the spray rig was only available on a limited number of days. Growers on the broad spectrum pesticide, calendar-type spray program tend to spray as soon as petal fall occurs. Sometimes the densities of citrus thrips do not warrant treatment. Growers who use biologically-based IPM can sometimes skip a citrus thrips treatment if they are monitoring their orchard very carefully and can do their own spraying on short notice if it is needed. Growers using the selective insecticides generally don't spray less frequently for citrus thrips, but because the insecticides are selective they allow natural enemies for other pests such as California red scale to survive and so they may spray less often for other pests.

Katydid nymphs can cause a great amount of damage in a very short amount of time because they prefer to feed on young fruit, take one bite out of each fruit, and move quickly throughout the tree. The natural enemies (parasitic wasps that attack the egg stage) are not always sufficient to keep their numbers below a damaging level. A timed search method is used by pest control advisors to detect katydid. If any are found and damage to fruit is occurring, then sprays are immediately applied. Orchards 4 & 5 had significant numbers of katydids (Table 2). Orchard 4 applied Kryocide for katydids in combination with Success for citrus thrips. Orchard 5 applied Baythroid for katydids in combination with Success for citrus thrips. In this region, no separate sprays were applied specifically for katydids. In both cases, the treatments were sufficient to keep katydids below detectable levels.

Citrus red mites were fairly low in this region in 2001, staying well below the economic threshold of 8 adult females per leaf. Thus, no treatments for citrus red mite were needed. However, in some years, when conditions are right, citrus red mite

outbreaks can occur following the use of broad spectrum insecticides for citrus thrips control. This is due to both the elimination of the predatory mites and a hormoligosis effect of the pesticides stimulating reproduction in the pest mites.

An average of 1.4 pesticide sprays were applied to each orchard in the Kern County area for early season pests (Table 1). Four orchards (2, 3, 4, and 7) utilized selective insecticides (Success, Veratran, Kryocide) and 6 orchards (1, 5, 6, 8, 9, 10) utilized broad spectrum insecticides (Baythroid, Lannate, Cygon, Danitol). We looked at fruit scarring both on the fruit while it was still on the tree and in the bins at harvest (Fig. 2). We use both methods of estimating damage because sometimes the fruit is harvested before we can get to the orchard and we miss that data. The two types of data can show differences in damage estimates because when we examine fruit on the tree we can't see the fruit inside of or on the top section of the tree. Fruit scarring due to citrus thrips (Fig. 2) was highest in orchards 3 and 9 when we examined fruit on the tree. When the fruit was examined in bins, thrips scarring was highest in orchards 1, 2, 3, 6 and 8. We would expect higher thrips damage to occur in orchards 2 and 3 where citrus thrips reached > 10% infested fruit (Fig. 1) before a spray was applied and in orchards 6, 8 and 9 where citrus thrips did not appear to be controlled by the first insecticide application. In orchard 1, citrus thrips were not observed yet damage occurred possibly due to use of the broad spectrum insecticide Lannate. With the exception of orchard 3, citrus thrips damage was less than 5% of the fruit. Thus, if growers treat once or twice for citrus thrips the damage was kept to a fairly low level.

Figure 2 also shows the level of katydid scarring damage of fruit. Orchards 3, 7, and 8 sustained the most katydid damage but it was less than 4% of the fruit. These orchards sustained damage despite the fact that weekly timed searches did not indicate there was a significant population of katydids in these orchards (Table 2). This points out the difficulty in finding katydids and predicting their damage potential. Katydid are extremely sensitive to organophosphate insecticides and pyrethroid insecticides. When organophosphates were commonly used for citrus thrips and red scale control, katydids were rarely seen. Now that growers are reducing these types of insecticides, katydids are becoming an increasing problem.

Scale Pests. Growers on the biologically based IPM program (Orchards 2, 3, and 4) release *Aphytis* wasps for California red scale every other week from March through October. They expect to see fairly high male scale counts (Fig. 3) because the parasites prefer to lay their eggs in female scales. Orchard 3 had very low levels of male scale. Orchard 2 had fairly low levels but they began to increase at the end of the year (September). Fruit in the Kern region matures earlier (Oct-Dec) than the Tulare region (Dec-Mar). Kern County growers consider *Aphytis* releases a high risk because the parasites may not clean up the scale on the fruit in time for harvest. The scale can be washed off in the packing house with a high pressure spray washer, however, this early fruit is easily damaged by this type of washing. Therefore, even though orchard 4 had a high level of parasitism (92% of 3rd instar scale parasitized in September) of the red scale and the percentage of scale-infested fruit was not increasing (Fig. 3, Table 3), the grower treated with Esteem. Of the orchards not releasing *Aphytis*, six (orchards 1, 5, 7, 8, and 10) had fairly low populations of scale as evidenced by male trap card counts (Fig. 3) and fruit counts (Table 3). Orchard 8 was treated with Esteem in spite of the fact that the male scale counts were extremely low and this treatment probably could have been

eliminated. Orchard 9 had a building population of California red scale as evidenced by the fruit counts and the male scale card numbers exceeding 2000/trap in the fall and so the infested half of the orchard was treated with Esteem. Orchard 6 male scale trap card counts in March were high (>100/card) and an Esteem treatment was applied which successfully protected the fruit from infestation.

The percentage of fruit infested with scale in orchards 2, 3, and 9 did not exceed 7% (Table 3) and the percentage parasitism of 3rd instar scale was $\geq 50\%$ in September. Thus, parasitism by *Aphytis* and *Comperiella* was good where scale was present and did not seem to be severely disrupted by the Esteem treatments or the Admire treatments applied for GWSS. Additional evidence that parasitism by these wasps is not severely affected by Esteem or Admire treatments is shown in Figure 4. In the first graph, we show data collected in 2000 in which a high rate (12 pints/acre) of the broad spectrum insecticide Lorsban was applied for scale control and *Aphytis* wasps were virtually eliminated. The second graph shows that *Aphytis* densities reached very high numbers in the fall of 2001 in the orchard in which *Aphytis* releases, a treatment of Esteem and two treatments of Admire were applied. Esteem and Admire are more toxic to predatory beetles than wasps. Thus, we are seemed to be trading California red scale as primary pest for cottony cushion scale or citricola scale where these insecticides are used.

Citricola scale is very easily killed by organophosphate insecticides. It is common to develop a citricola scale problem in the *Aphytis* release orchards because citricola scale has only one generation per year and natural enemies are not effective enough to control it. When organophosphate insecticide use stops, then citricola scale populations increase. Orchard 2 was treated midseason with Provado (Table 4) and Orchard 3 was treated with Lannate at the end of the season for citricola scale. These insecticides are likely to reduce effectiveness of natural enemies for next season. However, the growers needed to ship the fruit out of the GWSS-infested area and so they chose broad spectrum treatments that would control both citricola scale and GWSS. This is a good example of growers that are using a biologically-based IPM program that temporarily abandon their program to deal with an exotic pest.

A total of 0.4 treatments per orchard were applied for scale pests in the Kern region (Table 1). Both the on-tree and in-bin evaluations of CRS on fruit indicated that orchards 4 and 9 had the most damage due to CRS at harvest (Fig 2). If the growers have access to a high pressure washer, much of this scale can be washed off of the fruit. However, if the fruit is picked early (before January) as it was in orchard 4, the fruit quality declines if it is high-pressure washed. When we obtain the pack out data we will be able to see how the scaliness affected marketability of the fruit.

Glassy-winged sharpshooter. During 2001, several orchards began to deal with glassy-winged sharpshooter by applying the carbamate Lannate (orchard 1) and/or the systemic neonicotinoid Admire (orchards 1, 3, and 7) during the early part of the season (Table 1, Fig 5). The effect of the Lannate treatment was to eliminate all natural enemies. There were no secondary outbreaks following the Admire treatments, but there have also been no benefits of this application, since it only weakly controlled red scale in orchard 4 (Table 3). We expect secondary outbreaks of cottony cushion scale to begin to appear in 2002 in response to Admire, which is very toxic to vedalia beetles. Two orchards did not apply any broad spectrum insecticides during the early part of 2001 (orchards 2 and 3) and attained what the USDA considers high levels of GWSS (>1/tree)

(Fig. 5). Both of these orchards were treated with a broad spectrum insecticide (Provado in orchard 2 during August and Lannate in the fall in orchard 3) to control citricola scale and to eliminate GWSS in order to ship fruit to uninfested areas. Both treatments reduced natural enemies, but it is unknown if that effect will carry over into the next spring.

Glassy-winged sharpshooter has greatly increased the number of broad spectrum insecticide applications (+0.6/orchard) in the Kern County region (Table 1) and this is likely to cause problems with other pests next year because of the loss of natural enemies. A number of Kern County growers have abandoned their IPM program in order to suppress GWSS. Orchard 1 is a case in point. During previous years, this was an *Aphytis* wasp release orchard with occasional selective insecticides applied. Now the grower's goal is to suppress GWSS because of the neighboring grapes and the citrus treatment program is purely broad spectrum insecticide.

Tulare Region:

Early Season Pests. The year 2001 was a fairly severe katydid year for the growers in the Tulare region (Table 5). Those growers that had a katydid problem responded by using Baythroid (pyrethroid) as their citrus thrips treatment (orchard 8) or applying an additional low rate (a few oz/acre) of Lorsban as a separate spray or in combination with their thrips treatment (orchards 1, 5, and 6). Pyrethroids are fairly broad spectrum and have the effect of reducing natural enemies. Low rates of Lorsban are selective because many of the natural enemies have developed resistance to this pesticide. Thus, in orchards 1, 5, and 6 the low rate of Lorsban for katydid only briefly suppressed predatory mites needed for citrus thrips control (Fig. 6). These predatory mites are needed for citrus thrips and citrus red mite control and so are important to preserve. Reduced risk insecticides such as Success and Kryocide were not able to control this high level of katydid pressure in some orchards.

With careful monitoring, orchards 2 and 3 were able to avoid a citrus thrips treatment altogether (Fig. 6). Four orchards in the Tulare region used selective insecticides (Success) to manage thrips and very low rates of Lorsban to manage katydids. Three orchards used the broad spectrum insecticide Baythroid to manage citrus thrips and katydids. We did not see any evidence of thrips resistance to Baythroid in this region. Citrus thrips were not as heavy in this region compared to Kern County and no more than one treatment was needed in any of the orchards.

Figure 7 shows the densities of citrus red mites in 3 of the Tulare County orchards. The first graph shows natural control of citrus red mite by predatory mites, which were able to eliminate the mites by the end of May. The economic threshold is 8 adult female citrus red mites per leaf, and this density was never reached in 8 of 10 of the orchards. In the remaining two orchards (5 and 9), citrus red mites were very heavy in the early spring (March) before the predatory mite population began to expand. Predatory mites begin to increase when the trees begin to flush (April-May). The predatory mite densities were not high enough (<0.5/leaf) to assist with mite control and the citrus red mite densities were well above the economic threshold of 8 per leaf. Thus, corrective miticides were required (Vendex and Nexter). The Vendex was relatively nontoxic to the predatory mites allowing them to build as high as 2.5/leaf and assist with citrus thrips control. The Nexter was toxic to the predatory mites, but the residues began to wear off by May and predatory mites reached 0.4/leaf one month after treatment.

The total average number of early season sprays (Table 6) was only 1.1 in Tulare County (compared to 1.4 for Kern County). One orchard treated for ants using Lorsban granules. Seven orchards (1, 2, 3, 5, 6, 9, and 10) utilized selective insecticides (Success and/or a low rate of Lorsban) and 3 orchards (4, 7, and 8) utilized broad spectrum insecticides (Baythroid) for early season pest control. The fruit is not fully harvested in Tulare County so we can only look at the damage ratings of fruit on the tree taken in the fall. Fruit scarring due to katydids or citrus thrips in this region was very low (Fig 8). Even in orchards 2 and 3 that had very high densities of katydids, damage of fruit was very small. The Pest control advisor noted that the katydids were feeding on the flush rather than the fruit in those orchards and so he did not recommend a treatment. This is an excellent example of careful monitoring reducing overall pesticide use.

Scale Pests. Two orchards (4 and 6) were treated with Lorsban for California red scale (Table 6). However, the infestation of fruit in orchard 6 was undetectable (Table 7) and so it is questionable whether that treatment was necessary. Two *Aphytis* release orchards (1 and 2) were sprayed with oil early in the season both to thin the fruit load and to reduce the overall scale densities before *Aphytis* releases. This oil treatment will not likely be needed again. Growers on the biologically based IPM program (Orchards 1, 2, and 3) release *Aphytis* wasps for California red scale every other week from March through October. They expect to see fairly high male scale counts (Fig. 9) because the parasites prefer to lay their eggs in female scales. The percentage parasitism of 3rd instar scale was high 62-86% in October indicating that the parasitoid wasps were very effective this year. Orchards 7-10 had very low densities of red scale as shown both by male scale densities and fruit infestations (Fig. 9). Orchard 5 was treated with Supracide for cottony cushion scale and that treatment also affected red scale (Fig. 9). Only one orchard had densities of scale-infested fruit higher than 10% in October (Table 7).

Growers in this region commonly have problems with cottony cushion scale (Table 8). *Vedalia* beetles were present in May and June in two of the orchards but did not clean up the infestations completely. *Vedalia* need to arrive a bit earlier (March-April) in order to get full control of cottony cushion scale. Orchard (5) treated with Supracide to eliminate cottony cushion scale. As of the spring of 2002, there are four orchards that have low levels of cottony cushion scale and we plan to release *vedalia* beetles as part of the demonstration program in March. Esteem is known to stimulate outbreaks of cottony cushion scale because it prevents *vedalia* beetles from fully developing. Growers in this region have a tendency to have cottony cushion scale and they have seen a number of repercussions due to Esteem use, and so they tend to limit Esteem use.

Citricola scale is of concern in the *Aphytis* release orchards. However, densities during 2001 were low enough in the Tulare region that no treatments were needed.

A total of 0.5 treatments per orchard were applied for scale pests in the Tulare region (Table 6). On-tree evaluations of CRS on fruit indicated that orchards 1-4 had the most damage due to CRS at harvest (Fig. 8). This scaliness at harvest correlates well with the midseason male scale counts (Fig. 9) and the infestation of the fruit (Table 7), highlighting the importance and usefulness of these techniques for monitoring California red scale. Growers in the biologically based IPM program have confidence that the high pressure washer will remove the scale from the fruit and their long-term approach to red scale management will be more cost effective. When we obtain the pack out data we will be able to see how the scaliness affected marketability of the fruit.

- B. Problems that prevented the project from meeting objectives: none.
- C. Describe any changes to the established timetable and budget: none.
- D. Overall accomplishments and measures of success. We have only just begun the program and so are in the process of developing baseline data.

Task 3 Evaluate the Efficacy of Various Weed Management Strategies to Reduce Herbicide Use.

As part of the selection process of the cooperating growers for the demonstration program, not only was the arthropod pest management practice of the potential grower considered, but the weed management practices were considered as well. Within the ten cooperating growers in Tulare County, several weed management approaches are being utilized or considered. These practices include: application of a preemergence herbicide in the fall, spring or both; no preemergence herbicide application, with only the use of postemergence herbicides; relocation of the irrigation emitter under the tree canopy to eliminate irrigation in the sunlight area outside the canopies where weed seed is present; use of a cover crop to minimize runoff of winter rains from the orchard floor and possible associated preemergence herbicide.

A. Preliminary Results

Task 3.1 Demonstrate the efficacy of reduced herbicide use in row middles.

One Tulare County grower has planted two types of covercrop in the row middles of a portion of his orchard to reduce offsite movement of herbicides. The cover crop was seeded in mid November between the tree rows. One cover was comprised of clovers, vetch and brome and was planted in a strip two hundred feet from the border into the orchard. This treatment was repeated in four adjacent middles. Another cover was a mixture of oats, barley, triticale and vetch and was planted twenty feet into the orchard-this cover was alternated with the other cover in a four row treatment. Each of these treatments was replicated three times. The remaining area in the orchard not planted to cover crop was treated with a fall herbicide spray comprised of simazine and diuron-two preemergence herbicides. Catch basins were installed to capture runoff. Runoff is to be analyzed for presence of herbicide from each of the cover crop treatments and from the non cover treatment.

Task 3.2 Demonstration of reduced weed germination through relocation of emitters.

Two growers currently under a preemergence herbicide program agreed to relocation of irrigation emitters from their position between the trees in the tree row to a location under the tree canopy. Previous research has established that with this relocation weed growth in the former location is dramatically reduced and the need for application of herbicides as well. Research has also demonstrated that in mature orchards that have received herbicide applications for some years, the weed seed load has been reduced significantly with the level of remaining seed much higher in the tree row compared to the area between the rows. As a result, the application of the irrigation water under the canopy can eliminate water for weed seed germination and weed growth where the bulk of the seed is located.

Task 3.3 Demonstration of reduced numbers of herbicide applications.

Four of the cooperating growers use only postemergence herbicides for weed suppression. Glyphosate is applied three times to emerged weeds during the growing season. This program eliminates use of preemergence herbicides entirely and the associated potential of herbicide runoff from the orchard.

Three additional growers typically use both preemergence herbicides in the fall for winter weed suppression and post emergence herbicides are applied in the spring and summer. In two of these orchards when the fall preemergence spray was applied, the spray was omitted from the area between four rows on one end of the orchard. The remaining area of the orchard received the herbicide spray. The fall spray consisted of a combination of *simazine* and *diuron*, both preemergence herbicide materials. In these two orchards, weed growth in the treated and untreated areas will be compared.

Methods:

In the four orchards under a postemergence weed suppression program and in the three orchards under a preemergence regime, winter weed growth is being monitored as to weed species and relative abundance. A standard counting frame is being used to characterize weed growth. Growth within the frame is recorded as to species and abundance. Measurements with the frame are made at four sites for each treatment. In the three preemergence orchards, the weed growth in the non-treated as well as the treated areas is compared.

Monitoring of weed species and abundance will continue during the spring and summer in all seven orchards to track summer weed growth. In the two orchards in which irrigation emitters were relocated, weed species and abundance will be monitored in the area surrounding four tree canopies in the treated trees and adjacent trees with emitters not relocated.

In the orchard where the cover crop was seeded, runoff samples from the cover crop treated areas as well as the non cover/ herbicide treated area were collected and are being analyzed for the presence of herbicide. Data will be analyzed to determine if the presence of a cover crop offers significant benefit in mitigating the offsite movement of herbicide.

In the two orchards in which irrigation emitters were relocated, weed species and abundance will be monitored in the area surrounding four tree canopies in the treated trees and adjacent trees with emitters not relocated.

- B. Problems that prevented the project from meeting objectives: none.
- C. Describe any changes to the established timetable and budget: none.
- D. Overall accomplishments and measures of success. We have only just begun the program and so we do not have any data yet on the relative efficacy of these methods for reducing herbicide use.

Objective 4 and Task 4. Economic analysis of the various pest management strategies.

We conducted a grower meeting in Tulare County during the fall of 2001 with the Extension Economist on the project (Eta Takele) and developed a cost questionnaire that the Tulare County growers have completed. This questionnaire asks the grower for his costs for the pesticides, application of pesticide, water used to apply the pesticide, gasoline, *Aphytis*

releases, and pest monitoring. All of the data has been collected for the Tulare County region and is in the process of being analyzed. When we have the Tulare County data analyzed and have had a chance to see if the cost questionnaire is serving our needs, then we will collect the same data for Kern County.

Objective 5 and Task 5. Provide extensive outreach of the information gleaned from the demonstration orchards through newsletters, web pages, public meetings, TV, and radio.

1. Number of Cooperator meetings held (Meetings are roundtable discussions of current pest and natural enemy monitoring results):
 - a. Kern County Alliance Participants: 8 meetings (January-December 2001) held at the UCCE Extension office in Bakersfield. An average of 8 participants.
 - b. Tulare County Alliance Participants: 6 meetings (March-December) held at the Kearney Agricultural Center in Parlier. An average of 8 participants.
2. Field Days
 - a. Kern County September 19, 2001. 44 participants. ½ day session in which citrus growers and pest control advisors were invited to come to a 1 hour presentation of the Kern IPM Demonstration program at the Kern County Extension Conference room. The slide show was followed by a bus ride to a citrus orchard that was being treated with various rates of Admire for control of glassy-winged sharpshooter. The final segment of the tour was a visit to a Pierce's Disease infected vineyard.
 - b. Tulare County: September 25, 2001. 62 participants. ½ day session in which citrus growers and pest control advisors were invited to come to a 1 ½ hour presentation of the Tulare IPM Demonstration project at the Orosi Veterans Memorial Hall. The slide show was followed by a gathering at a Pest Management Alliance orchard where minimal sprays had been applied and *Aphytis* parasites were released. The pest control advisor (Robert Walther) explained how the program is conducted and the grower (Keith Harrison) gave a testimony as to how switching to a biologically-based IPM program has reduced his costs and improved his fruit packout. Insect specimens including vedalia beetles, *Aphytis* wasps, citricola scale, cottony cushion scale and various types of fruit damage were on display.
3. Presentations to growers
 - Grafton-Cardwell, E. E., Kern County Extension Seminar, Bakersfield, CA. February 1, 2001. Talk: "Summary of the Kern County IPM Demonstration Program".
 - Grafton-Cardwell, E. E. Citrus Research Board Project proposals and reports, Riverside, CA. March 13, 2001. "Citrus IPM demonstrations for Kern and Tulare Counties".
 - Grafton-Cardwell, E. E., Spring Citrus Meeting, UCCE Tulare Co., Exeter, CA. April 27, 2001. Talk: "Pest Management considerations, 2001".
 - Grafton-Cardwell, E. E. Citrus IPM Update and the Glassy-Winged Sharpshooter in the citrus-grape interface. September 19, 2001, Bakersfield CA. Talk: Integrated Pest Management Project Update. Field Site visit.
 - Grafton-Cardwell, E. E. Citrus Pest Management Demonstration. September 25, 2001. Orosi, CA. Talk: Citrus IPM Demonstration Program. Field Site visit.
 - O'Connell, N. V. Fall Citrus Meeting. October 23, 2001. Tulare, CA. Talk: "Tulare County Citrus Integrated Pest Management Demonstration".

4. Publications

- a. Web site (www.uckac.edu/citrusent). The monitoring results for glassy-winged sharpshooter and parasites, citrus thrips, citrus red mite, predatory mites, California red scale and parasites, citricola scale and parasites, cottony cushion scale and vedalia beetles, citrus peelminer, katydids, and citrus cutworm are updated every week. The insecticide treatments are listed and the response of pests and beneficials to these insecticides are discussed.

Kern Demonstration Web Pages

Kern Main Page: www.uckac.edu/citrusent/kern2001home.htm

Glassy-winged sharpshooter counts: www.uckac.edu/citrusent/gwss2001.htm

Citrus red mite counts: <http://citrusent.uckac.edu/kcipmcrm01.htm>

Citrus thrips counts: <http://citrusent.uckac.edu/kernthrips01.htm>

Katydid counts: <http://citrusent.uckac.edu/kernkaty01.htm>

Citricola scale counts: <http://citrusent.uckac.edu/kerncitric2001.htm>

California red scale counts: <http://citrusent.uckac.edu/kcipmcrs01.htm>

Citrus cutworm counts: <http://citrusent.uckac.edu/kccutworm2001.htm>

Miscellaneous Pest counts:

http://citrusent.uckac.edu/miscellaneous_insect_pestsk2001.htm

Tulare Demonstration Web Pages

Tulare Main Page: <http://citrusent.uckac.edu/tularechomesecndtry.htm>

Citrus red mite counts: <http://citrusent.uckac.edu/tularecrmsecnd01.htm>

Citrus thrips counts: <http://citrusent.uckac.edu/Tularethrips01.htm>

Katydid counts: <http://citrusent.uckac.edu/tulkatydid2001.htm>

Citricola scale counts: <http://citrusent.uckac.edu/tularecitr01.htm>

California red scale counts: <http://citrusent.uckac.edu/tularecrs01.htm>

Citrus cutworm counts: <http://citrusent.uckac.edu/tulareworm01.htm>

Cottony cushion scale counts: <http://citrusent.uckac.edu/tulareccs01.htm>

Miscellaneous Pest counts: <http://citrusent.uckac.edu/tulmiscpests2001.htm>

- b. Grafton-Cardwell, B. 2000. IPM project begins in Kern County. Citrograph 85: 10-11.
- c. Plant Protection Quarterly article: Grafton-Cardwell, B., C. Reagan, C. Kallsen, and M. Bartels. Glassy-winged sharpshooter in San Joaquin Valley citrus. KAC Plant Prot Quart. 11(2): 4-7. This publication can be viewed on the website: <http://www.uckac.edu/ppq/PDF/01April.pdf>

C. Discussion:

The Pest Management Alliance Citrus program was very successful this first year. There was a high level of interaction among the grower and pest control cooperators and University of California Extension personnel. The field days we conducted that described the current results of the project were very well attended. The web site was checked on at least a weekly basis by hundreds of growers and pest control advisors. We were able to show that only a few of the insecticide treatments in the cooperating orchards were not needed indicating that growers use restraint in their pesticide use. We demonstrated that growers in the Tulare and Kern areas utilize a number of different insecticide tactics. For example, Tulare County growers tend to use low rates of Lorsban for katydid control, whereas Kern Co. growers tend to use the pyrethroids

Baythroid or Danitol. We showed that the Lorsban treatment is more IPM compatible because it is a very low rate and many of the predators and parasites have resistance to it. Lorsban is a critically needed IPM tool for moderating both katydid and citricola scale populations. Both of these pests have very poor biological control and are very sensitive to low rates of Lorsban. Another example of a difference between regions is the avoidance of Esteem in the Tulare region, which has a greater problem with cottony cushion scale. Esteem is very toxic to vedalia beetles needed for cottony cushion scale control. Finally, we documented the toll that the glassy-winged sharpshooter treatments are taking on the IPM program in Kern County. GWSS treatments are increasing insecticide use by an average of 0.6 treatments per orchard and unhappily the insecticides that work most effectively against GWSS are the most toxic to natural enemies. We have not completed the economic analysis of the two regions because the fruit is still being harvested.

Growers were chosen for the program because they utilize a variety of pest management tactics ranging from biologically-based to broad spectrum insecticides. Interestingly, no matter what technique is used, the number of insecticide treatments applied is roughly the same. This is because growers that use soft insecticides and parasite releases tend to have problems with pests with poor biological control (katydids and citricola scale) and growers that use broad spectrum insecticides have trouble with pests that develop resistance easily or that are not well controlled by insecticides (citrus thrips and cottony cushion scale). When these pests get out of control, additional insecticides are needed. In general, in the absence of exotic pests such as glassy-winged sharpshooter, insecticide use in citrus is fairly low (<2 applications per season). Growers showed, for the most part, great restraint in insecticides use, waiting in most cases for economic thresholds to be reached.

Biologically-based, sustainable IPM practices are fairly well-developed for San Joaquin Valley citrus. Thus, the techniques are known to work, they are just not always chosen by growers or economically feasible. For example, *Aphytis* wasp releases do help to control California red scale and reduce infestations. However, it is currently cheaper to spray with Esteem every third year than it is to release *Aphytis* wasps every year. Thus, the growers who adopt the *Aphytis* release program do so because they believe in a long-term sustainable approach, they want to avoid insecticide resistance problems, and problems of secondary pest outbreaks. In Kern County, if the fruit is to be harvested and shipped to packing houses in areas of California that are currently not generally infested with glassy-winged sharpshooter, then the must be disinfested with a broad spectrum insecticide. These types of economic and quarantine issues sometimes render the biologically-based IPM program unpalatable or unworkable.

D. Summary and Conclusions:

Alternative practices that were utilized by the cooperators included releases of *Aphytis* wasps, use of low rates of Lorsban to moderate katydid populations, releases of vedalia beetles for cottony cushion scale control, careful monitoring to reduce citrus thrips treatments, use of oils and insect growth regulators instead of organophosphate and carbamate insecticides for California red scale control. Five of the cooperators also began trials to reduce herbicide use and offsite movement of herbicides by relocating irrigation emitters, planting covercrop, or eliminating pre emergence herbicides in portions of their orchards.

Summary of the project success. We had 20 participating growers (10 in Tulare Co. and 10 in Kern Co.) in the PMA program with a total acreage of 250 acres. Eleven of the orchards

used reduced risk insecticides coupled with intensive monitoring activities (130 acres). These techniques included releases of Aphytis wasps (6 orchards), avoidance of broad spectrum insecticides in the early season or use of extremely low rates of Lorsban (11 orchards), use of insecticides on only the infested portion of the orchard (2 orchards). As the season progressed and glassy-winged sharpshooter began to affect insecticide choices in Kern County, three of the orchards abandoned their IPM strategy. The total number of acres managed by these growers is 10,000. The estimated acreage under reduced risk activities by these growers is 4,000 acres. The number of participating PCAs in the project is 15. The number of field days held was 2 with approximately 120 attendees. The number of additional workshops and meetings was 14 with an average attendance of 8 of the cooperators or pest control advisors. The number of newsletters was 4, the number of articles 2, and the number of presentations 6.

The cost assessment has not been completed yet because not all of the orchards in the program have been harvested.

A web site (www.uckac.edu/citrusent/) was updated weekly. It contains 18 pages describing all of the pest densities and management practices for each of the 20 orchards.

1) Proposal Title

**Southern San Joaquin Valley
Citrus Pest Management
Alliance**

Project Summary Form

2) Principal Investigator

Elizabeth E. Grafton-Cardwell

3) Alternative Practices

Releases of *Aphygis* wasps for control of California red scale, use of oils and insect growth regulators instead of organophosphate and insecticides Carbamate insecticides for red scale, releases of vedalia beetles for cottony cushion scale control, use of ultra low rates of chlorpyrifos instead of pyrethroids for katydid control, careful monitoring to avoid treatments for citrus thrips, planting of cover crop or careful placement of emitters to reduce herbicide use, elimination of pre emergence herbicides to mitigate off-site movement.

4) Summary of Project Successes

We were able to demonstrate that the biologically-based IPM program of arthropod pest management results in relatively low fruit injury. The reduced risk program does not necessarily result in fewer insecticide applications, but avoids insecticide resistance problems and secondary pest outbreaks. The requirements for disinfestation of glassy-winged sharpshooter from citrus in order to ship fruit from Kern County is causing a number of growers to abandon IPM.

5) Number of Participating Growers

20

12) Number of Field Days

2

6) Total Acreage in Project

250

13) Attendance at Field Days

120

7) Project Acreage Under Reduced Risk

130

14) Number of Workshops & Meetings

14

8) Total Acres of Project Crop

10,000

15) Workshop Attendance

112

9) Non-Project Reduced Risk Acres

4,000

16) Number of Newsletters

4

10) Number of Participating PCAs

15

17) Number of Articles

2

11) Cost Assessment

18) Number of Presentations

6

The cost assessment has not been completed yet because the crop is not fully harvested.

19) Other Outreach Activities

Website (www.uckac.edu/citrusent) was established and 18 pages updated on a weekly basis.

FOR OFFICIAL USE ONLY

Contract Number _____ Project ID _____

DPR ID# _____ Contract Manager _____ 25th May 2001

Figure 1. The impact of early season 2001 insecticide treatments for citrus thrips, katydid, and glassy-winged sharpshooter on citrus thrips densities and predacious mites in Kern County.

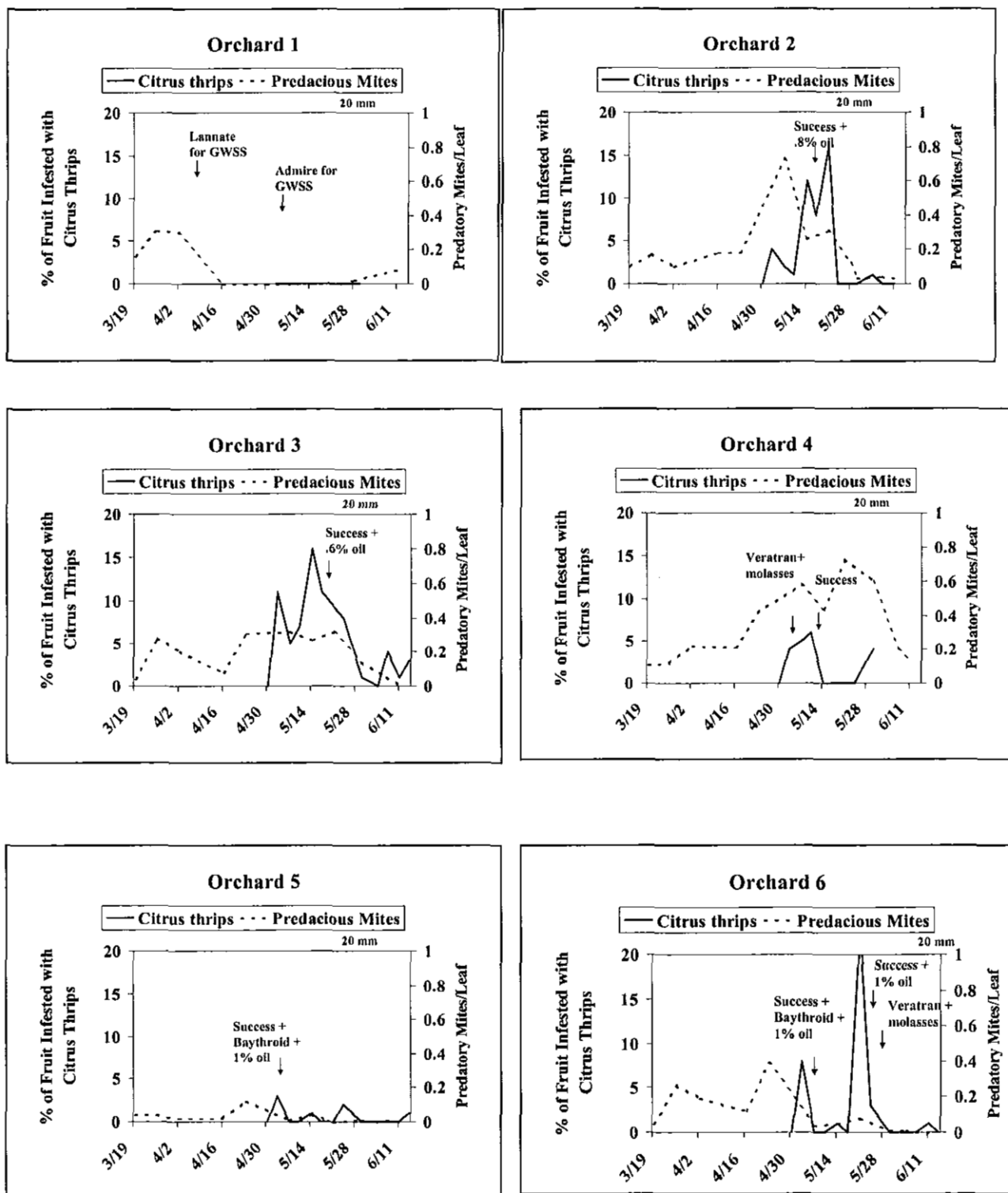


Figure 1 (continued).

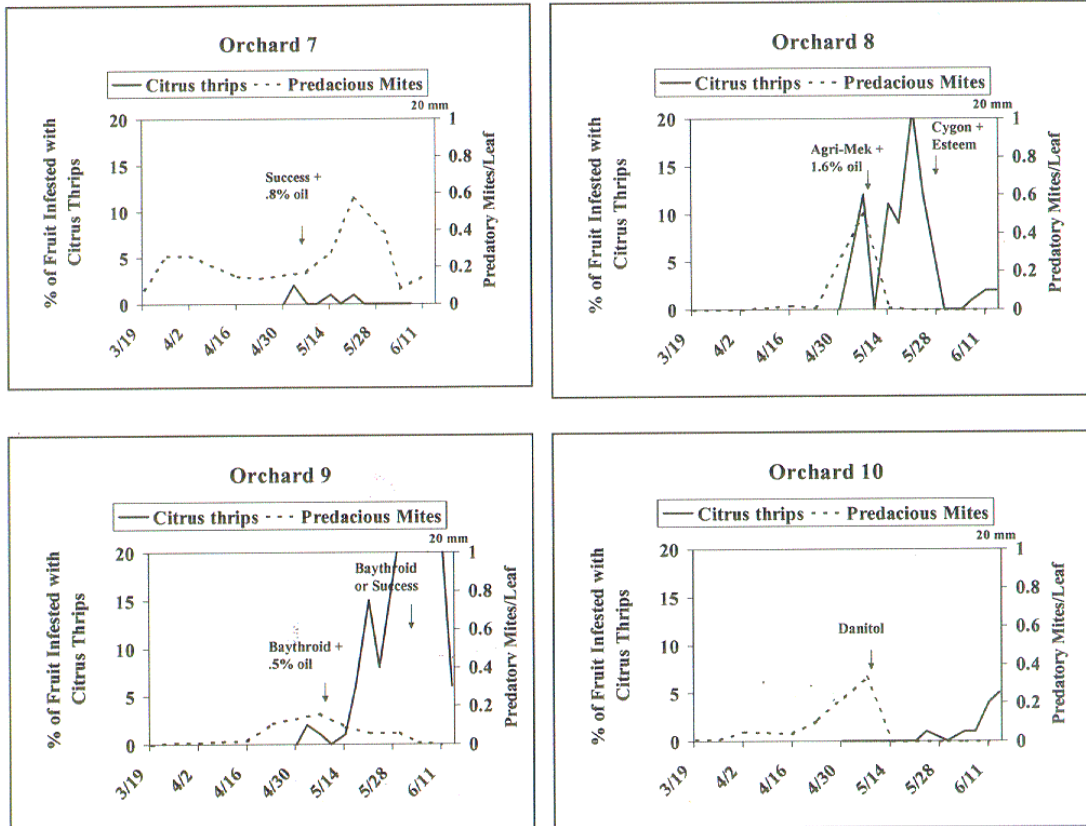


Figure 2. Fruit damage due to various arthropod pests (or mechanical damage due to wind scarring and equipment) in the Kern County Orchards. The top graph shows the damage ratings taken while fruit is still on the tree. The bottom graph shows the damage ratings of fruit in bins as it was being picked.

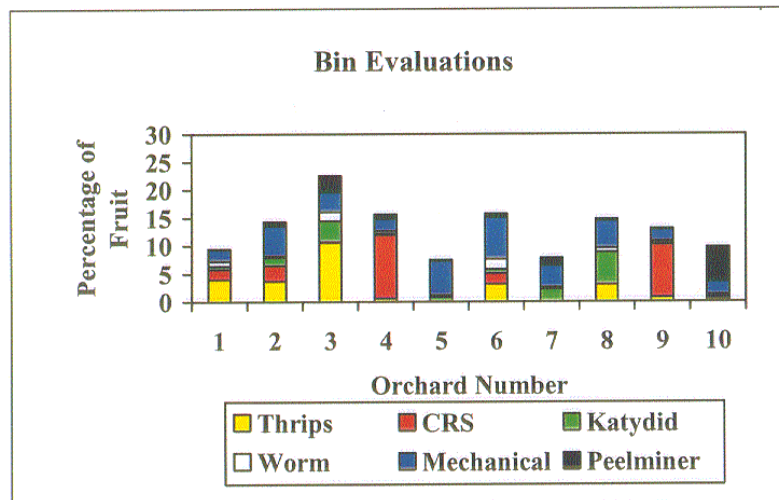
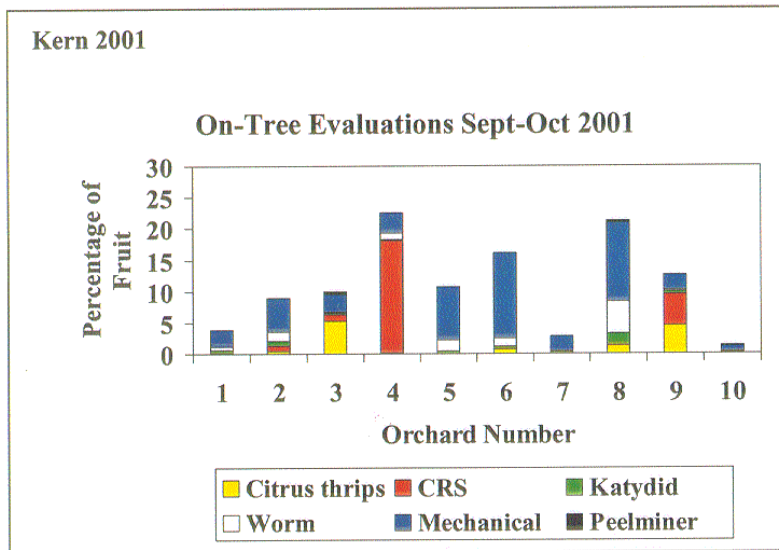


Figure 3. Densities of Male scale found on pheromone trap cards throughout the season. Insecticide treatments, *Aphytis* wasp releases, and the percentage of fruit infested with live California red scale are noted.

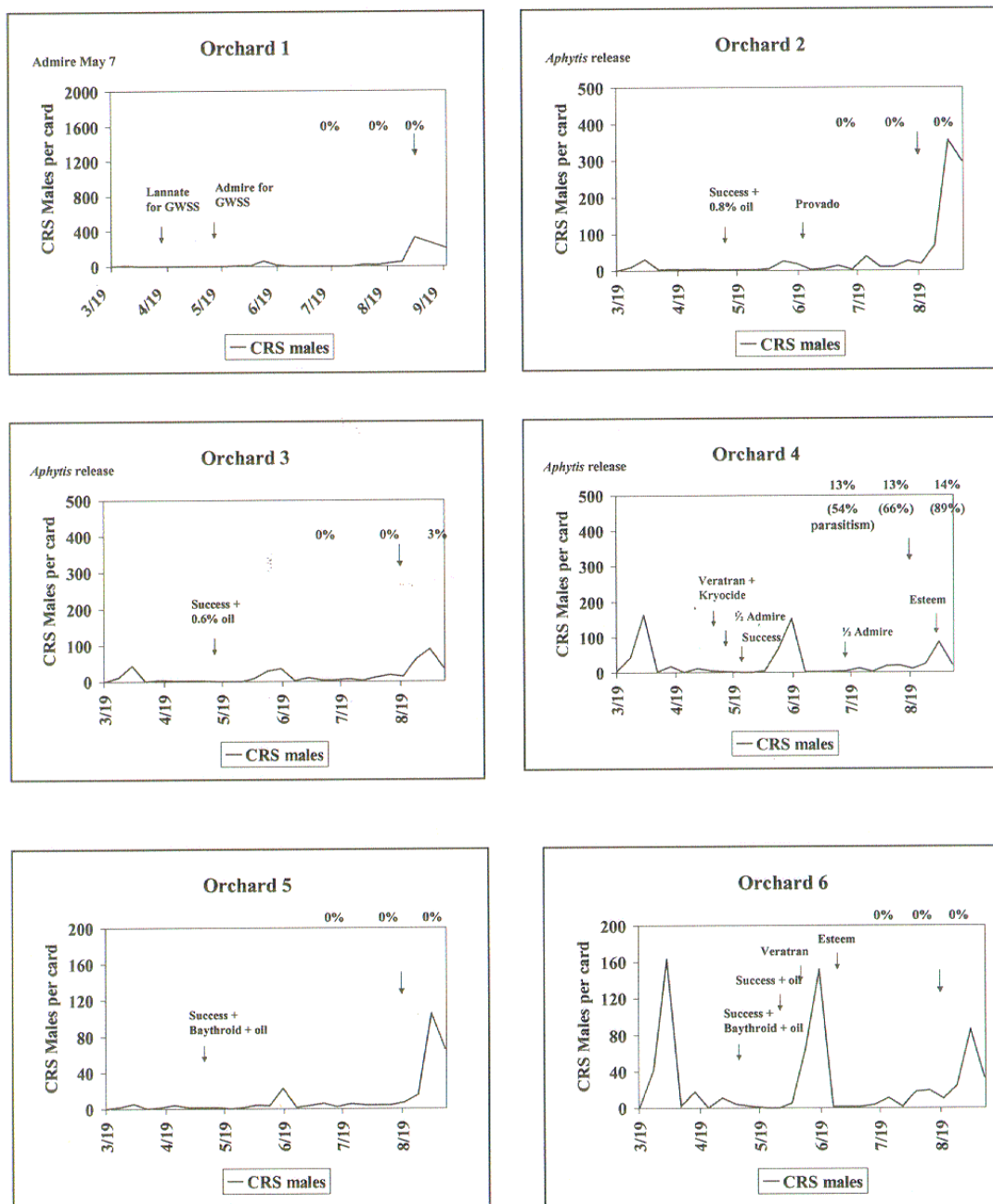


Figure 3 (continued).

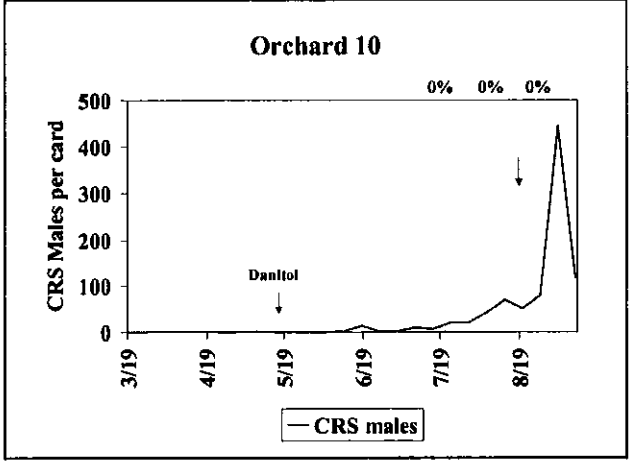
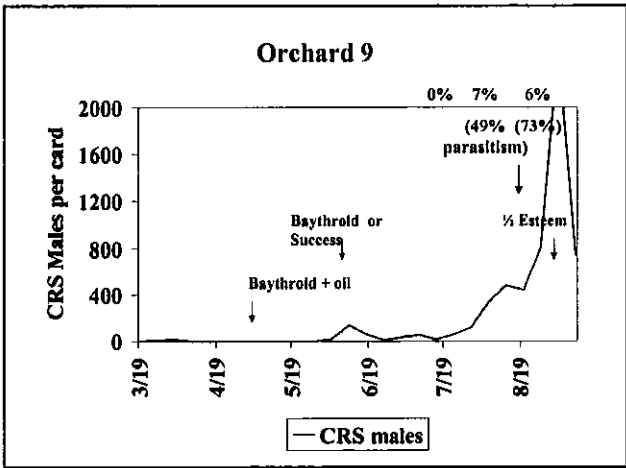
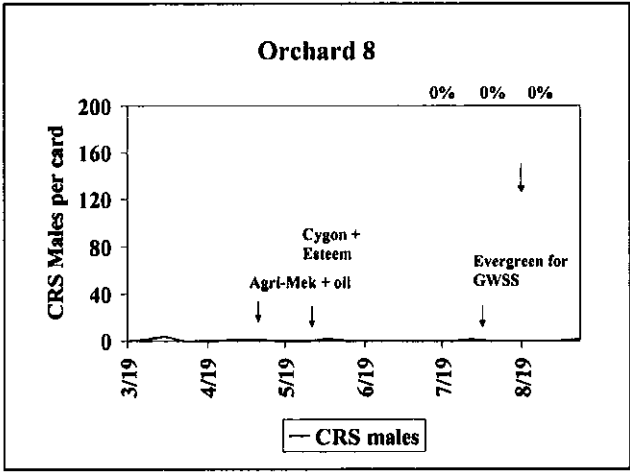
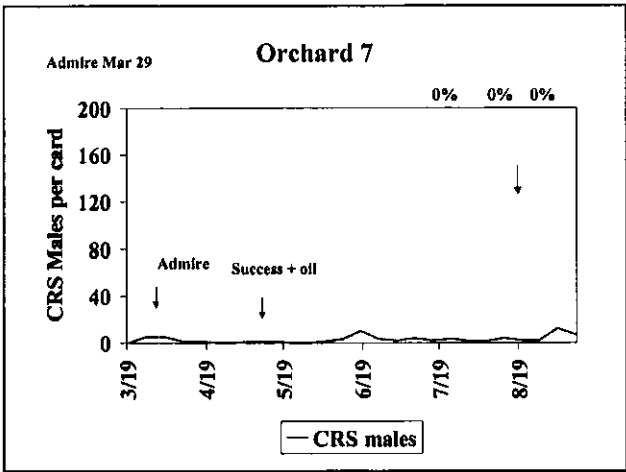


Figure 4. The effects of Lorsban in a Kern 2000 orchard versus the effects of Esteem and Admire in a Kern 2001 orchard on *Aphytis* wasp densities. Counts of *Aphytis* and *Comperiella* wasps are collected on yellow sticky cards changed monthly.

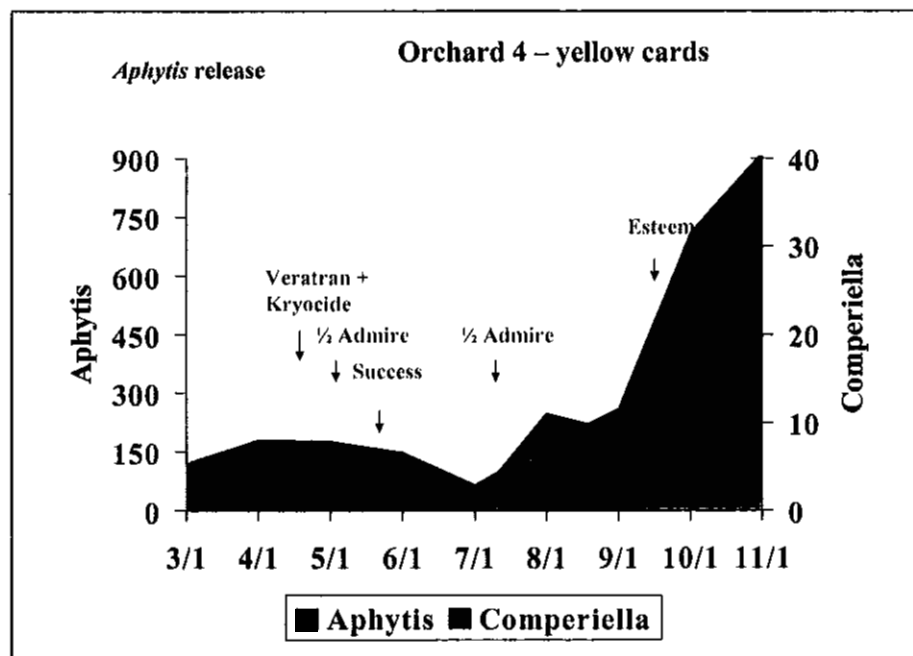
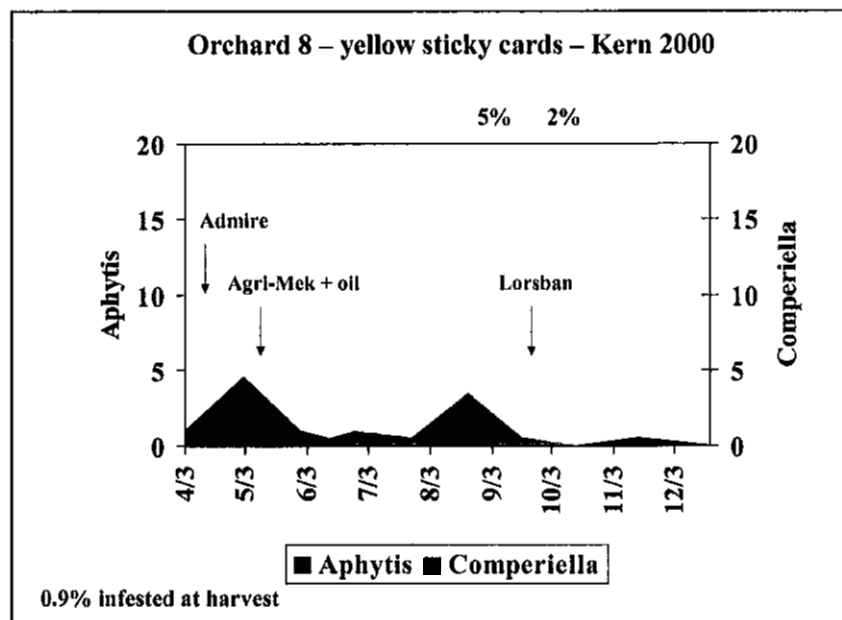


Figure 5. Glassy-winged sharpshooter nymph and adult densities in the Kern County demonstration orchards.

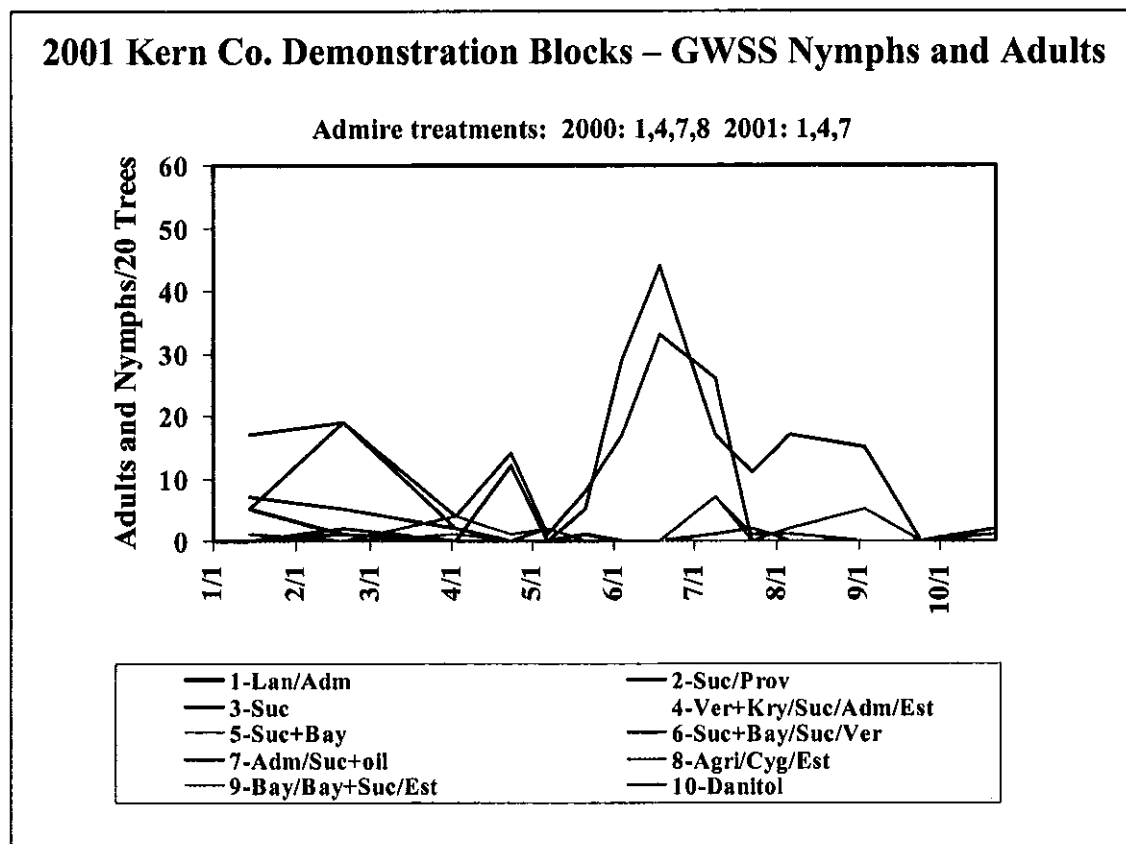


Figure 6. The impact of early season 2001 insecticide treatments for citrus thrips, katydid, and citrus red mite on citrus thrips densities and predacious mites in Tulare County.

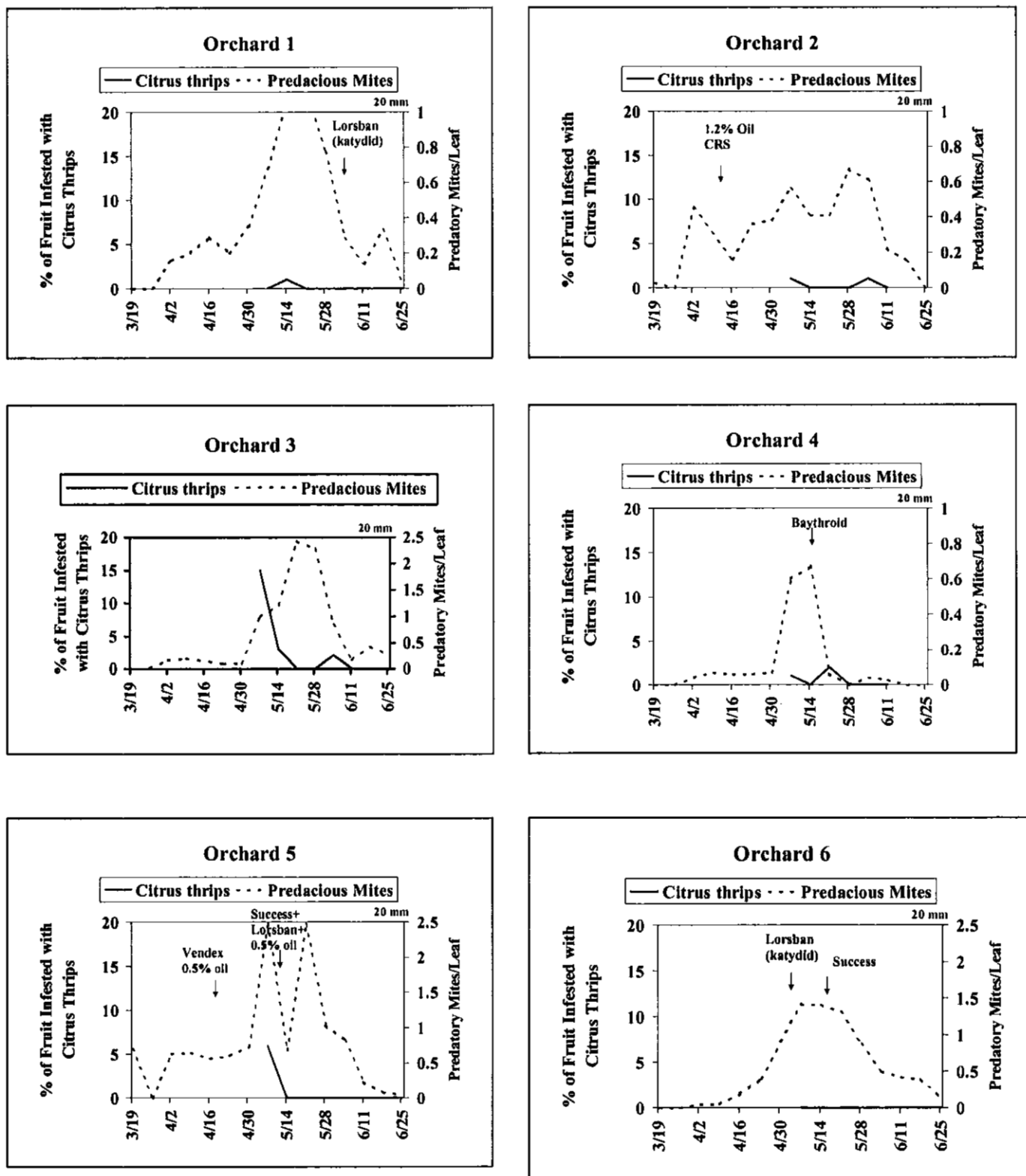


Figure 6 (continued).

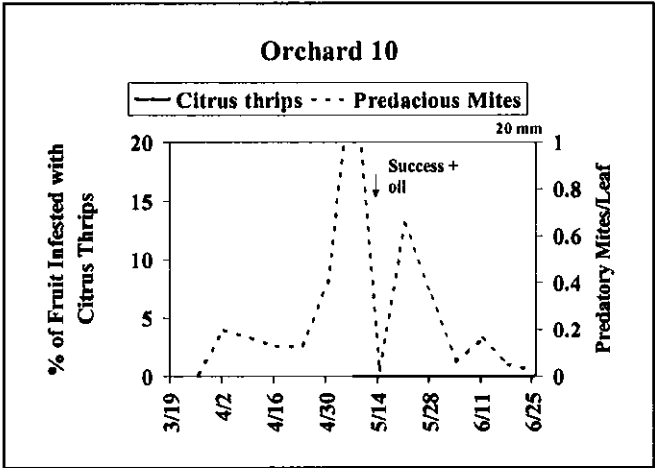
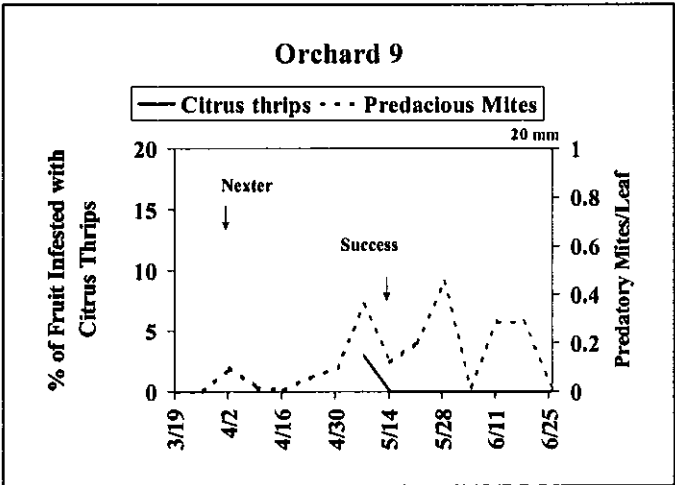
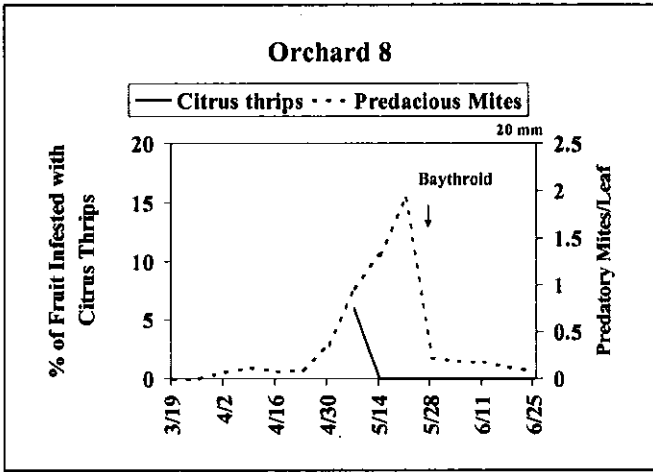
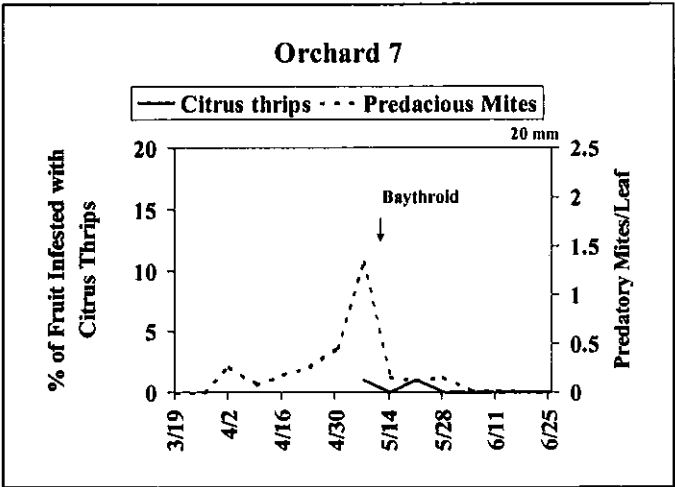


Figure 7. Densities of citrus red mite and predatory mites in several Tulare County demonstration orchards.

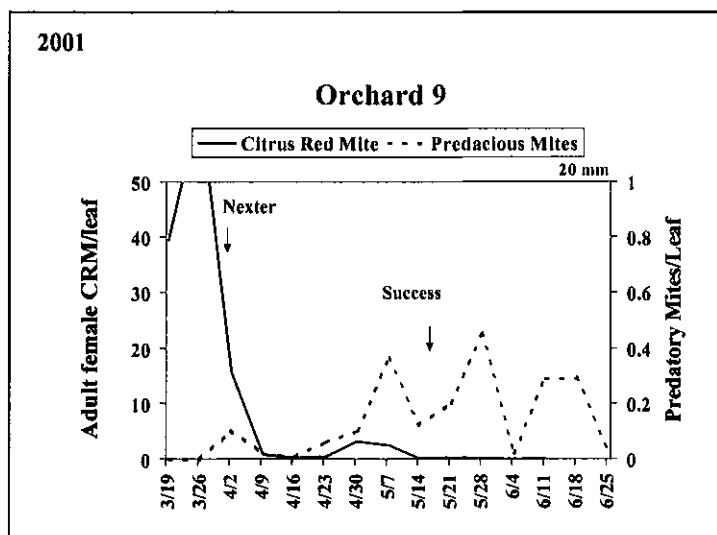
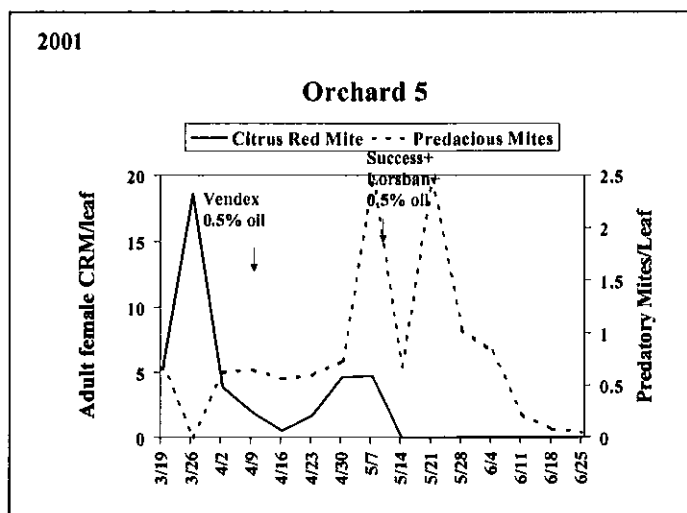
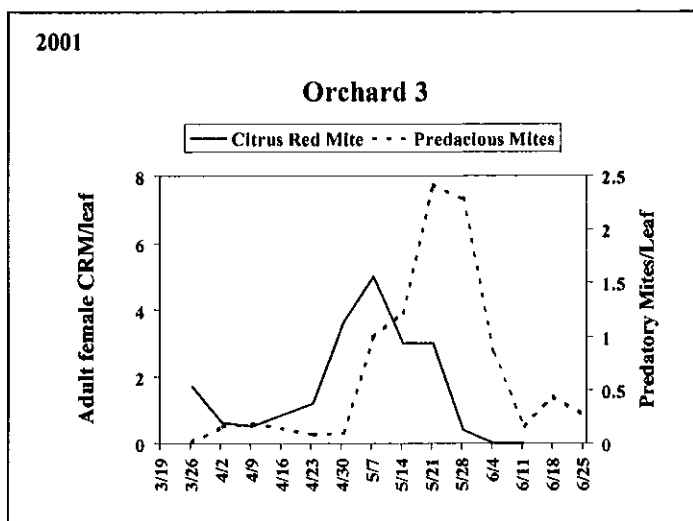


Figure 8. Evaluations of fruit damage taken by examining fruit on 20 trees in each orchard in Tulare County.

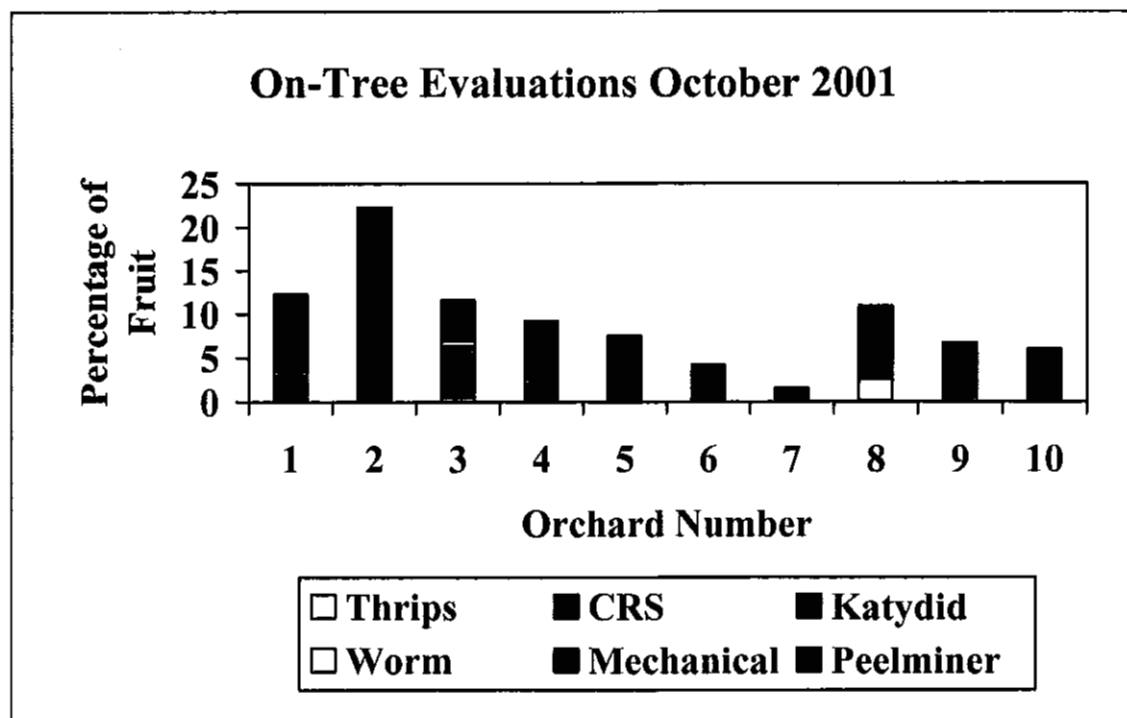


Figure 9. Densities of male California red scale on pheromone traps collected in the Tulare County orchards in 2001. Insecticide treatments, *Aphytis* wasp releases, and percentage of fruit infested with scale are noted.

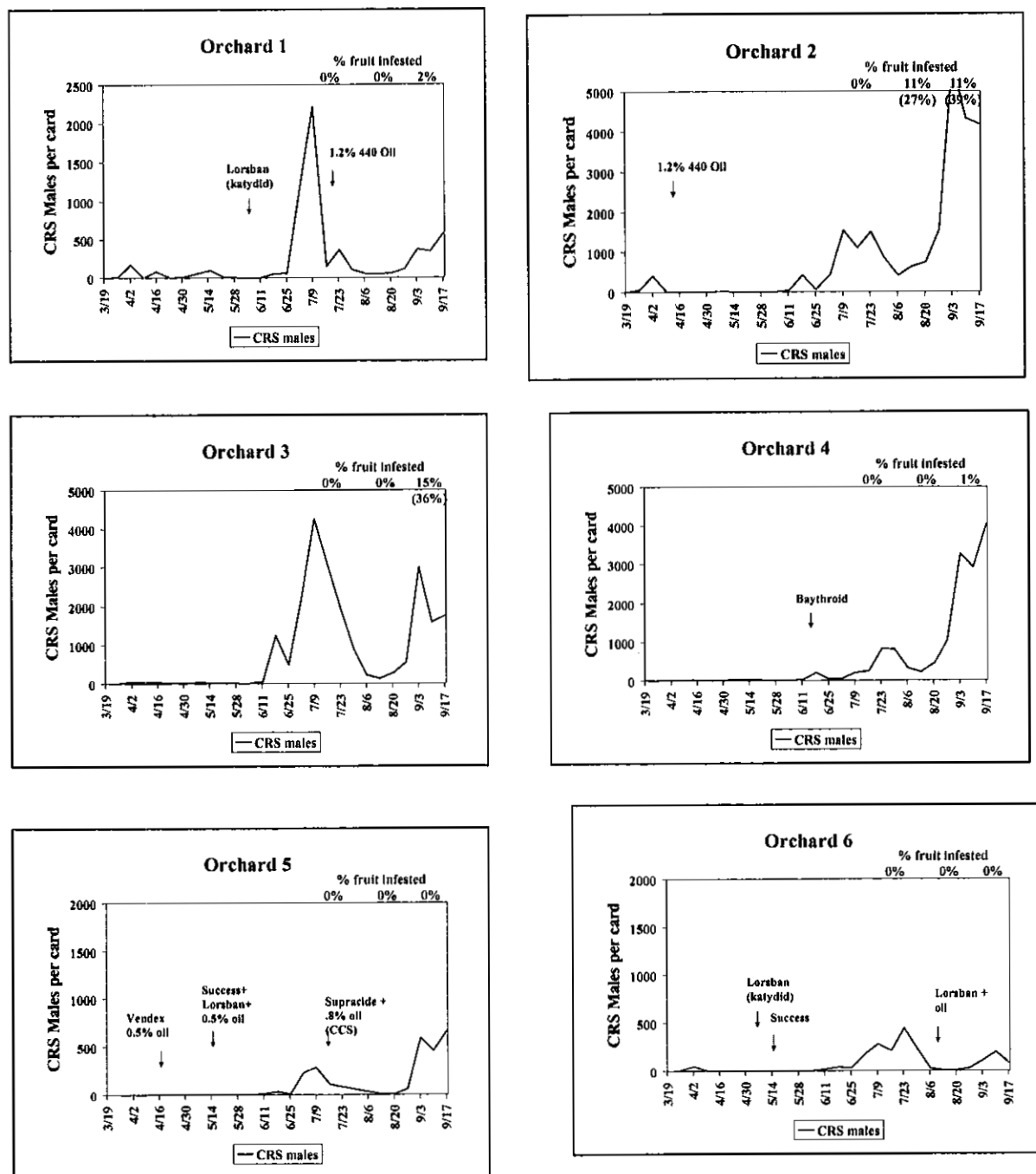


Figure 9 (continued)

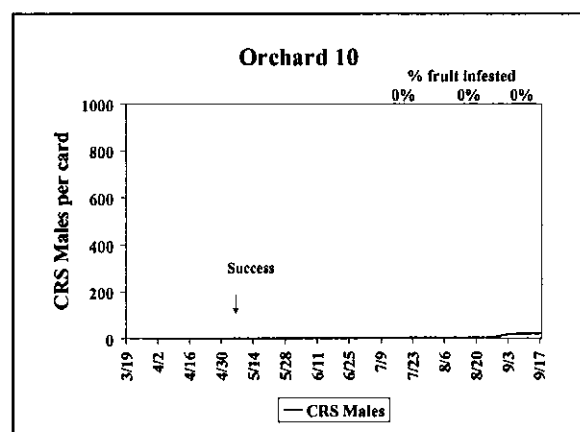
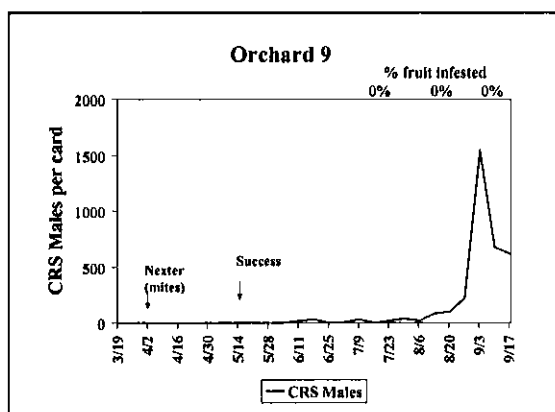
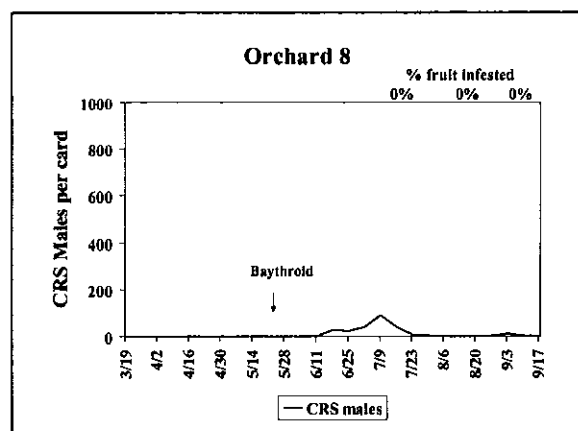
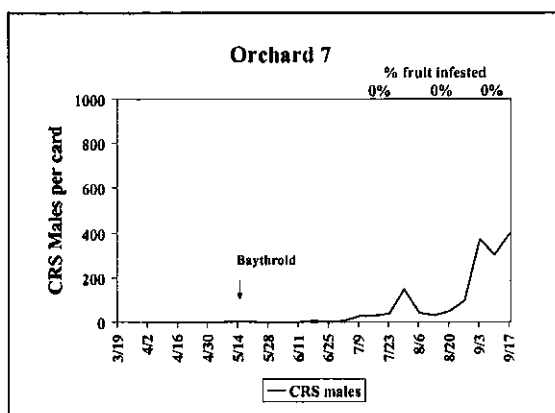


Table 1. Pesticide applications and *Aphytis* wasp releases conducted in the 10 Kern County orchards during 2001. The grower in Orchard 1 is applying insecticides to aggressively reduce GWSS. Orchards 2-4 are releasing *Aphytis* wasps and conducting a biologically-based IPM program. Orchards 5-7 are minimizing the number of insecticide applications through careful monitoring. Orchards 8-10 tend to use broad spectrum insecticides to control pests.

BL	Citrus Thrips/Katydid	CRS	Citricola	Total	GWSS
1				0	Lannate Admire
2	Success+.8% oil	Aphytis	Provado	2 + Aphytis	
3	Success +.7% oil	Aphytis		1+ Aphytis	Lannate
4	Veratran+Kryocide Success	Aphytis +Esteem		3+ Aphytis	Admire Admire
5	Success+Baythroid+oil			1	
6	Success+Baythroid+oil Success +oil & Veratran	Esteem		4	
7	Success+.8% oil			1	Admire
8	Agri-Mek+1.6%oil Cygon	Esteem		3	
9	Baythroid+oil Baythroid/Success	Esteem		3	
10	Danitol			1	
Avg	1.4	0.4	0.1	1.9 + Aph	0.6

Table 2. The number of katydids seen during a 2 minute search of each of 20 trees in each orchard on several dates before and after insecticide treatments were applied for citrus thrips and/or katydids.

2001 – Kern County						
Number of katydids seen during a 2 minute search of each of 20 trees						
BL	Apr 16	Apr 23		May 10		May 21
1	0	0	Lannate	0		0
2	2	0		0	Success	0
3	0	0		1	Success	0
4	0	4	Kryocide	0	Success	0
5	0	5	Baythroid/ Success	0		0
6	0	0	Baythroid/ Success	0		0
7	0	0	Success	0		0
8	0	1		0	Cygon	0
9	0	0	Baythroid	0		0
10	0	0		0	Danitol	0

Table 3. Percentage of fruit infested with California red scale (% parasitism by *Aphytis* and *Comperiella* wasps). Insecticide treatments for California red scale and glassy-winged sharpshooter and *Aphytis* releases for California red scale are shown.

% Fruit Infested with CRS (% parasitism)						
BL	July	Aug	Sep	Oct	CRS	GWSS
1	0	0	0	0		Lannate Admire
2	0	0	0	1	Aphytis	
3	0	0	3% (50%)	1	Aphytis	Lannate
4	13% (54%)	13% (66%)	14% (92%)	18% (89%)	Aphytis +Esteem	½ Admire ½ Admire
5	0	0	0	0		
6	0	0	0	0	Esteem	
7	0	0	0	0		Admire
8	0	0	0	0	Esteem	
9	0	7% (49%)	6% (73%)	5% (55%)	Esteem	
10	0	0	0	0		

Table 4. Citricola scale densities in the Kern County orchards.

2001- Kern % Leaves infested with citricola scale								
BL	June	July	Aug	Sep	Citricola	Thrips	CRS	GWSS
1	3%	0	0	0				Lannate Admire
2	79%	*16%	24%	14%	Provado	Success	Aphytis	
3	43%	66%	83%	75%		Success	Aphytis	Lannate
4	1%	0	0	0		Veratran Success	Aphytis +Esteem	Admire Admire
5	0	0	0	0		Suc/Baythr		
6	0	0	0	0		Suc/Baythr	Esteem	
7	0	0	0	0		Success		Admire
8	0	0	0	0		Agri-Mek Cygon	Esteem	
9	0	0	0	0		Suc/Baythr	Esteem	
10	0	0	0	0		Danitol		

Table 5. Densities of katydids seen during a 2 minute search of each of 20 trees in the Tulare County demonstration orchards 2001.

2001 – Tulare County								
Number of katydids seen during a 2 minute search of each of 20 trees								
BL	Apr 9	Apr 16	Apr 23	Apr 30	May 7	May 14	May 21	May 28
1	0	2	4	8	4	11	3	Lorsban*
2	0	0	2	6	2	6	6	5
3	0	-	3	5	1	17	14	0
4	0	0	0	8	0	Baythroid	1	0
5	0	1	3	0	2	Success +Lorsban*	2	0
6	0	13	18	Lorsban*	0	Success	0	0
7	0	2	0	2	0	Baythroid	4	1
8	0	1	0	1	1	4	Baythroid*	0
9	0	2	1	3	0	Success	3	5
10	0	0	0	0	Success	3	0	0

Table 6. Pesticide applications and *Aphytis* wasp releases conducted in the 10 Tulare County orchards during 2001. Orchards 1-3 are releasing *Aphytis* wasps and conducting a biologically-based IPM program. Orchards 4-7 are minimizing the number of insecticide applications through careful monitoring. Orchards 8-10 tend to use broad spectrum insecticides to control pests.

BL	Citrus Red Mite	Citrus Thrips	Katydid	Ants	CRS/CCS	Total sprays
1			Lorsban		Aphytis 1.2% 440 oil	2
2				Lorsban	Aphytis 1.2% 440 oil	2
3					Aphytis Esteem(border)	
4		Baythroid			Lorsban	2
5	Vendex +0.5% oil	Success+ Lorsban+ 0.5% oil	(Lorsban)		Supracide + oil	3
6		Success	Lorsban		Lorsban + oil	3
7		Baythroid				1
8		Baythroid	(Baythroid)			1
9	Nexter	Success				2
10		Success + oil				1
Avg	.2	.7	.2	.1	.5	1.7

Table 7. % Infestation of citrus fruit with California red scale (% parasitism of 3rd instar scale by *Aphytis* and *Comperiella* wasps).

2001 % Fruit Infested with CRS (% parasitism of 3 rd instars)						
BL	July	Aug	Sep	Oct	CRS	CCS
1	0	0	2%	3% (62%)	Aphytis 1.2% 440 oil	
2	0	11% (27%)	11% (39%)	18% (86%)	Aphytis 1.2% 440 oil	
3	0	0	15% (36%)	5%	Aphytis Esteem (border)	
4	0	0	1%	2%	Lorsban	
5	0	0	0	0		Supracide
6	0	0	0	0	Lorsban + 1% oil	
7	0	0	0	0		
8	0	0	0	0		
9	0	0	0	0		
10	0	0	0	0		
					Aphytis + .4	.1

Table 8. Percentage of trees infested with cottony cushion scale in the Tulare County orchards during 2001. Vedalia beetles were present in some orchards until July.

2001- Tulare Co. % Cottony cushion scale infested trees							
BL	Apr	May	Jun	Jul	Aug	Sep	CRS/CCS
0	50%	55% (V)	35% (V)	45%	8%	10%	Aphytis 1.2% 440 oil
2	0	0	0	0	0	5%	Aphytis 1.2% 440 oil
3	0	0	0	0	5%	5%	Aphytis Esteem (border)
4	0	0	0	0	0	0	Lorsban
5	25%	20% (V)	55% (V)	10%*	0	0	Supracide + oil
6	0	0	1	0	0	0	Lorsban + oil
7	0	0	0	0	20%	15%	
8	0	0	0	0	0	0	
9	0	0	0	0	0	0	
10	0	10%	0	0	0	0	

(V) = vedalia beetles present